BARBER COLMAN

INSTRUCTION MANUAL

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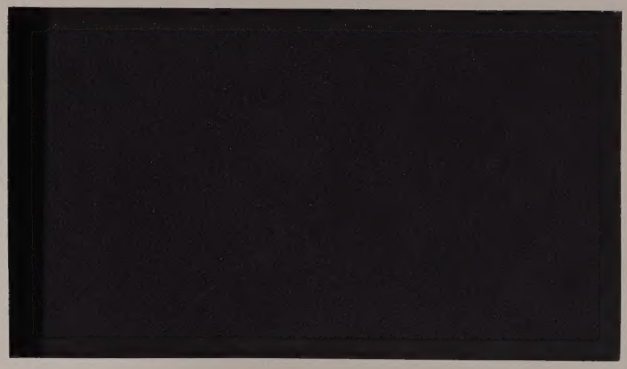
MA32116

BARBER-COLMAN COMPANY
Industrial Instruments Div. • Rockford, Ill., U.S.A.



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MODEL 472P CAPACITROL

INTRODUCTION

This instruction manual is designed to help you secure maximum benefits from your new Model 472P Capacitrol. It should be given to persons responsible for installation and maintenance of this instrument.

Your Barber-Colman factory trained field engineer is always available for further help in the solution of your control problems. Offices are located in all principal cities.

BARBER-COLMAN COMPANY
Industrial Instruments Division

Litho in U.S.A.

F-12635-1 - April 1965

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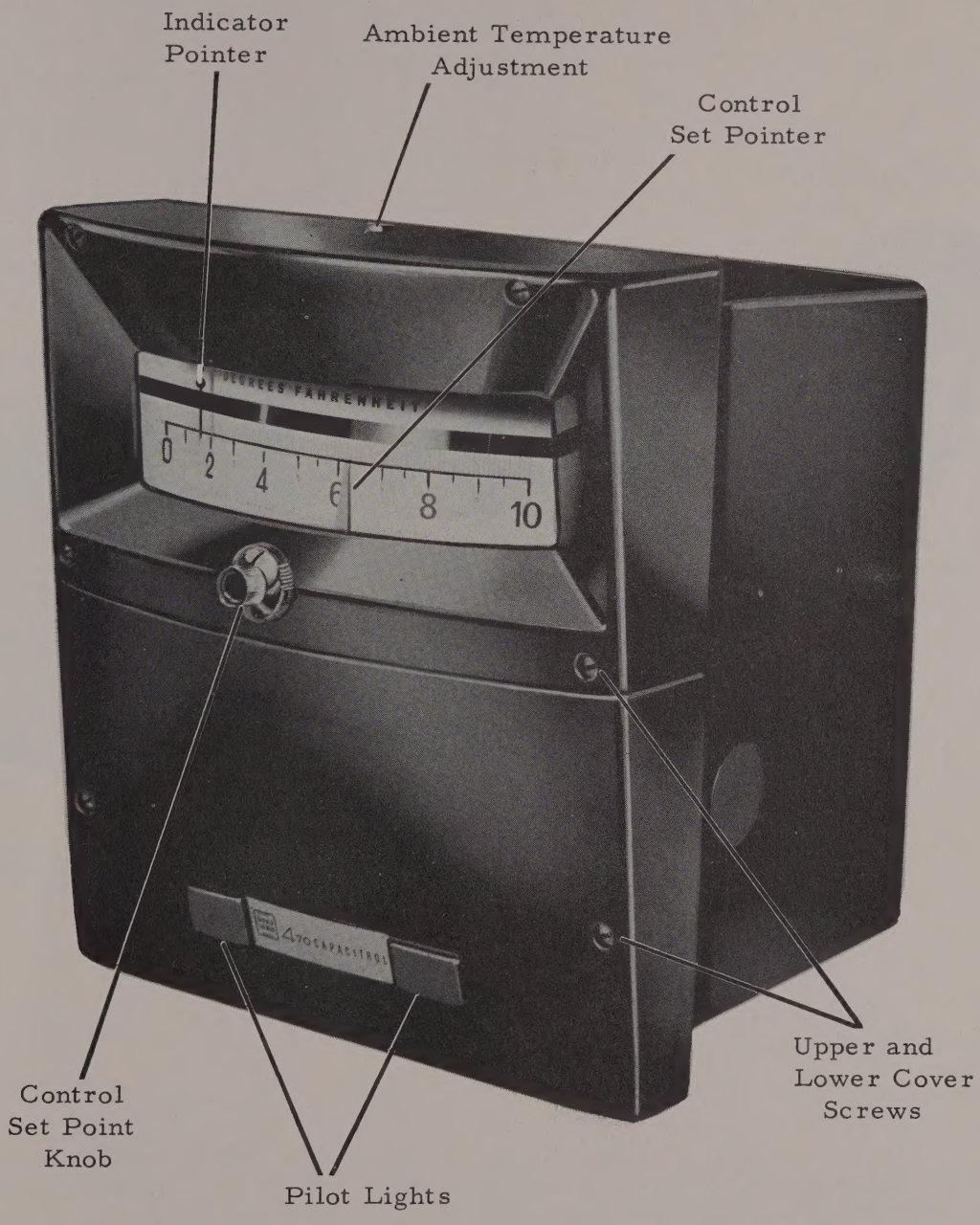

SERIES 470P CAPACITROL

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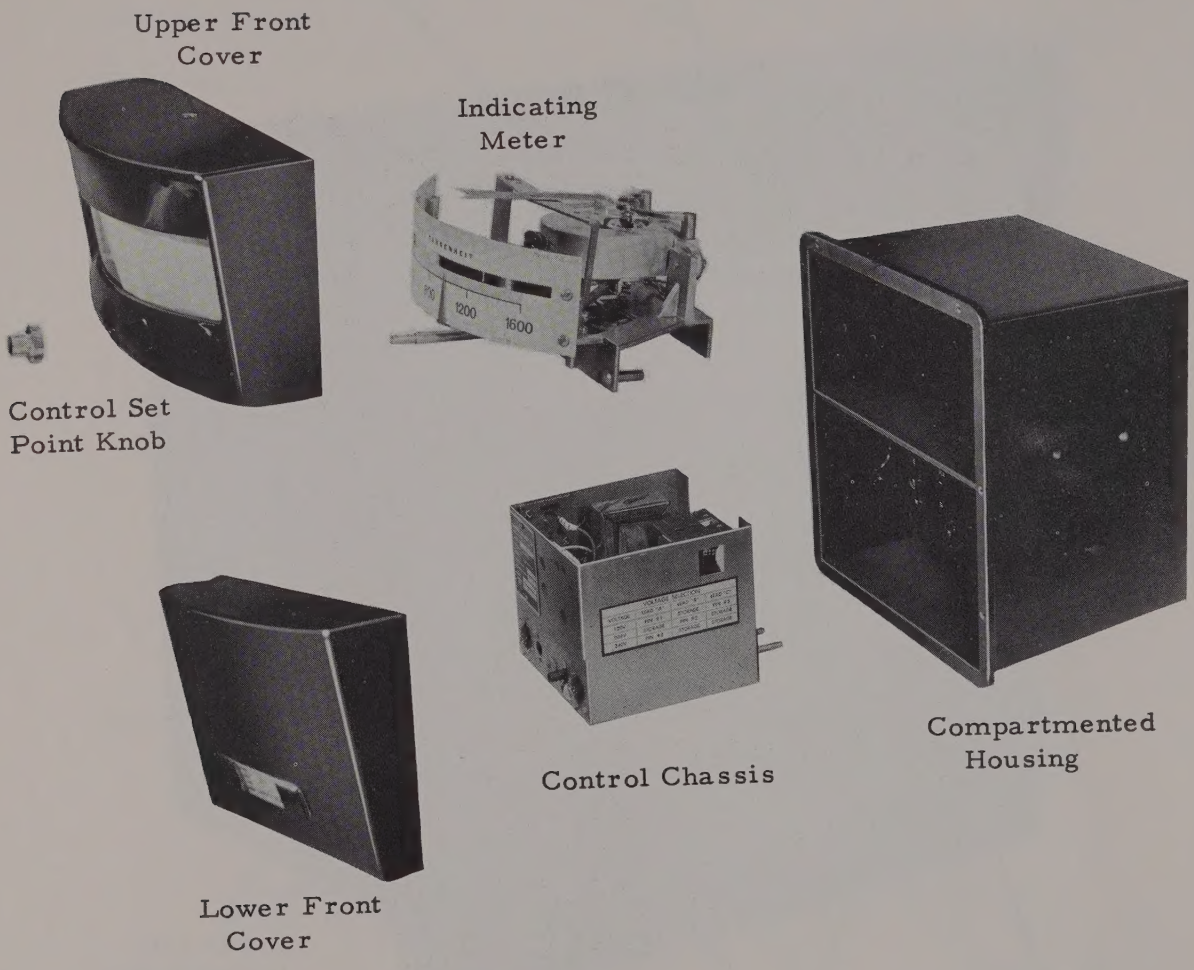

MODEL 472P

MAJOR COMPONENTS

SPECIFICATIONS

Meter

Scale Length	6 inches
Minimum Span	9 mv or 0-300°F - Type J
Calibrated Accuracy	± 1/2% of full scale
Sensitivity	50 microamps for full scale deflection (nominal)
Internal Resistance	20 ohms per millivolt (nominal)
External Resistance	a) As standard, calibrated for 15 ohms and supplied with replaceable compensator to make up difference between calibrated resistance and actual value of external resistance. May be calibrated for other values of external resistance if required. b) Units with bridge type TCB are adjustable for external resistances up to 20 ohms
Compensation	a) Automatic cold junction temperature compensation -- mechanical standard; electrical optional. Range 40 to 130°F b) Copper coefficient compensation. Range 40 to 130°F
Thermocouple Break Protection	Standard type TCB furnished unless otherwise specified. Bridge type TCB available.

Chassis

Control Sensitivity	0.1 of 1% of full scale
Control Contacts	One set of SPDT contacts

Contact Ratings	120 v	240 v
Resistance loads	5 amps	2.5 amps
Inductive loads	2.5 amps	1.25 amps

Proportioning Band	Adjustable from 0.5% to 5% of full scale
Cycle Time	5% PB - adjustable from 3 to 12 seconds 0.5% PB - adjustable from 30 to 120 seconds
Control Adjustment	External control set point knob adjustable over 100% of scale. Reset control internally adjustable
Power Requirements	9 volt amperes
Power Supply	Interchangeable: 120, 208, 240 volts a-c, 50 - 60 cycle

Dimensions and Weights

Overall Dimensions	9 15/16" high x 9 5/8" deep x 9" wide
Cutout for Flush Mounting	8 1/4" wide x 9 1/4" high
	Note: Meter housing will extend approximately 6" into panel when flush mounted
Net Weight	Approximately 16 pounds
Shipping Weight	Approximately 23 pounds

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DESCRIPTION

General Description

The Model 472P Capacitrol is a millivoltmeter-type indicating on-off or two position controller which has a time proportioning feature incorporated in the unit so load temperature variations can be minimized. The unit employs a solid state trigger type circuit to operate a relay with single pole double throw action.

The instrument is suitable for any application compatible with this relay action including the operation of external relays, contactors, solenoid valves, valve control motors or any electrical load which does not exceed the instrument relay ratings.

Control Specifications

The 472P output utilizes a SPDT relay with a contact rating of 5 amperes at 120 volts, or 2.5 amperes at 240 volts for a non-inductive load such as a small electric heating element. For inductive loads such as solenoid valves or contactors, these ratings are decreased 50%. Three adjustments, "reset", "cycle time" and "proportioning band" are adjustable from the front of the instrument and their operation is described under Control Adjustments. The proportioning band is adjustable from 0.5% to 5% of full scale. The instrument cycle time is adjustable from 3 to 12 seconds at a 5% PB setting and from 30 to 120 seconds at a 0.5% PB setting. Control action occurs when the meter indicator is within the proportioning band range of the instrument, the location of which is determined by the red control set pointer. After the controlled load has become thermally stable, any offset between the meter indicator and the red control set point can be corrected with the reset adjustment.

The control point can be easily adjusted through the full length of the instrument scale by means of a setting knob located just below the scale. Red and green signal lights indicate, respectively, on and off control action. The relay contacts are connected to terminals 1, 2 and 3 on the rear terminal strip.

Description of Electronic Circuit

The Model 472P uses a transistorized oscillator and a silicon controlled rectifier (SCR) for control of the load temperature. At a position on the scale below control point, the transistor collector current is great enough to trigger the silicon controlled rectifier, energizing a relay so that power is applied to the load or process. As the indicator approaches control set point a small vane or flag, suspended from the indicating pointer, passes between two flat coils mounted on the control set arm. The presence of the flag between the coils changes the tuning of the oscillator circuit. With the flag fully between the coils, the collector current decreases to a point where the SCR ceases to conduct, de-energizing the relay and reversing the process.

Time proportioning occurs when the flag traverses a distance, fixed by the PB setting, between the coils as discussed under Time Proportioning Control.

Proportioning action is accomplished by changing the tuning of the transistor's emitter circuit. A voltage-variable capacitor is used for this purpose. Adjusting the proportioning band determines the amount of d-c voltage that can be applied to the voltage capacitor and the change in capacitance that can occur, thereby determining the tuning range of the emitter circuit. The "cycle time" adjustment regulates the d-c voltage applied over a certain period and hence determines the cycling rate.

Time Proportioning Control

Time proportioning action occurs when the flag is between the coils, and its position in the coils automatically determines the percent on time versus off time during one cycle, or the period of time power is applied to the controlled load. After the indicator has reached the proportioning band (with the flag between the coils) and moves upscale towards the control set point, the percent on time decreases and the percent off time increases. At control point, this would be approximately 50% on and 50% off. This action, called "time proportioning" results in a modulation of power to the controlled load, minimizing overshoot and undershoot for close tolerance control.

An illustration of time proportioning action is shown in Figure 1. The illustration shows a proportioning band setting at its maximum of 5% of full scale, (40°F ÷ 800°F) x 100 = 5%, which means that full power is applied to the load at 580°F and no power at 620°F. If the proportioning band was decreased to its minimum of 0.5% of full scale and was set for 50% on time at coincidence (when control set pointer coincides with the meter indicator), the time proportioning would vary from fully on at 598°F to fully off at 602°F as the meter indicator moved upscale. The time of one cycle would also increase when the proportioning band is decreased.

In the example shown, the time of one complete cycle is 8 seconds. It could be adjusted, however, to over 12 seconds or decreased to 3 seconds. The time period that power is applied to the load is thereby controlled, so that temperature variations are minimized. These adjustments are described further under the section on Control Adjustments.

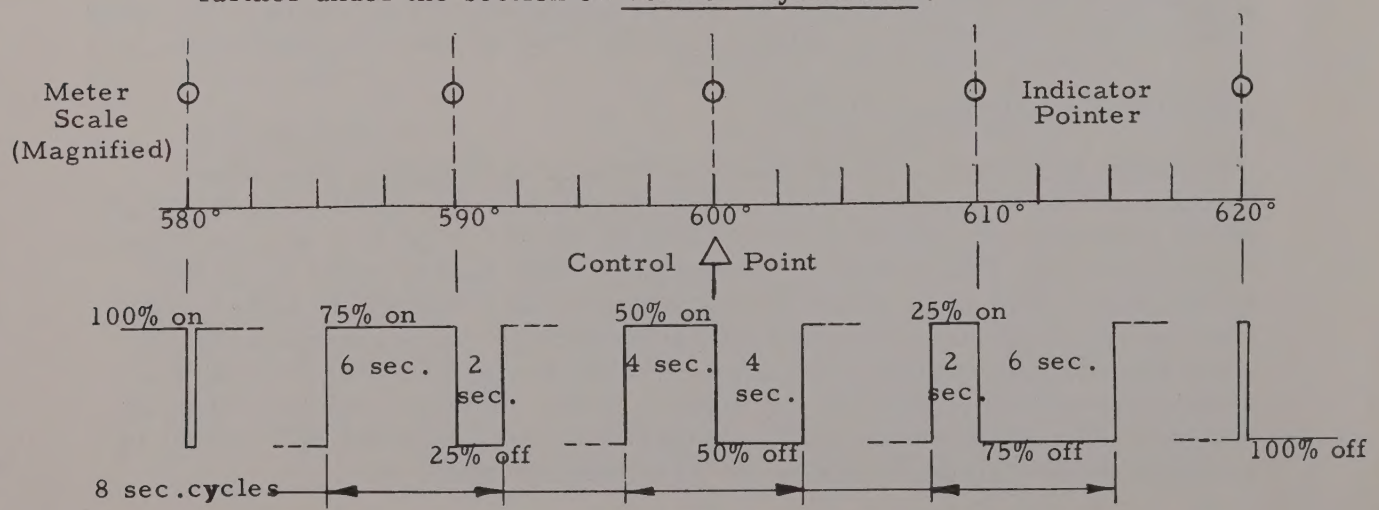

Figure 1
EXAMPLE OF TIME PROPORTIONING ACTION AS THE METER INDICATOR MOVES UPSCALE THROUGH THE PROPORTIONING BAND OF A 0-800°F METER

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Unpacking the Instrument

This precision instrument and its associated equipment have been carefully manufactured and packed at the factory. Remove the instrument and accessories from the packing box and check items against the packing slip. If the equipment is found to be damaged in transit, report damages to the carrier immediately. Repack in original packing box until ready for installation.

Caution:

Handle with care.
Safeguard instrument from shock before and after installation.
Avoid oil accumulation and exposure to moisture.
Keep instrument temperature under 130°F and over 40°F.

Mounting Instructions

Locate instrument to avoid excessive vibration, shock and temperatures outside the range of 40°F to 130°F. Avoid furnace walls, radiation of heat, machine frames and outside walls. Provide suitable shelter against moisture and temperature extremes if installed outdoors. Refer to appropriate drawing for mounting details.

Power Wiring

The instrument is wired for 120 volts a-c. If available power supply is other than this, the proper voltage can be selected as follows:

The lower front cover should be removed by loosening the two screws. The chassis assembly can then be removed by firmly pulling forward. A voltage selection board is located on the top left side of the chassis. The voltage can easily be changed by plugging the wires onto the proper pins as shown on the right side of the chassis enclosure and as illustrated in Figure 2.

The two marked pins #1 and #2 are used for the voltage range desired while the other pins are used for storing the unused wires. The wires are marked A, B and C. The connections are as shown below:

VOLTAGE SELECTION

Voltage	Lead "A"	Lead "B"	Lead "C"
120 v	Pin #1	Storage	Pin #2
208 v	Storage	Pin #2	Storage
240 v	Pin #2	Storage	Storage

Figure 2

After the proper voltage has been selected and the chassis replaced the instrument is then ready for wiring. The instrument will operate on both 50 and 60 cycle a-c systems. The desired a-c supply voltage is connected to terminals L1 and L2 inside the lower compartment. If the instrument is equipped for back wiring, remove the back panel to expose the terminal strips. All wiring should be in accordance with the applicable electrical codes. It is recommended that a fused switch be inserted in the power line to the load. The fuse size should never exceed 5 amperes at 120 volts or 2.5 amperes at 240 volts. If load requirements are less than these amounts the ampere rating of the fuse can be less. Where maximum protection of the instrument is desired a 1/8 ampere fuse may also be added in the power line to the instrument.

Solid wire is recommended for instrument wiring. If stranded wire is used, tin the ends to provide secure connections.

The instrument should be grounded. This is accomplished by attaching the ground terminal (G) directly to a good ground, such as a cold water pipe.

Caution: Do not connect the ground terminal to the neutral a-c line.

Terminals 1, 2 and 3 are wired internally to the relay contacts with terminal 2 as the common point of the SPDT contact. Terminal 1 is the normally closed contact and terminal 3 the normally open contact as shown in Figures 3 and 4. The external wiring diagram (Figure 7) shows some typical wiring diagrams.

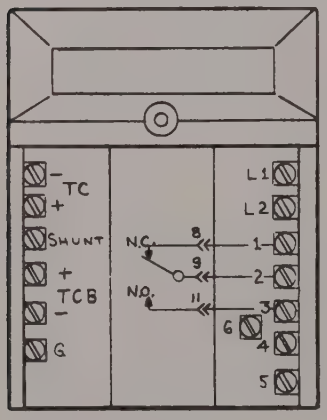


Figure 3

Model 470 Capacitrol
with
Standard TCB

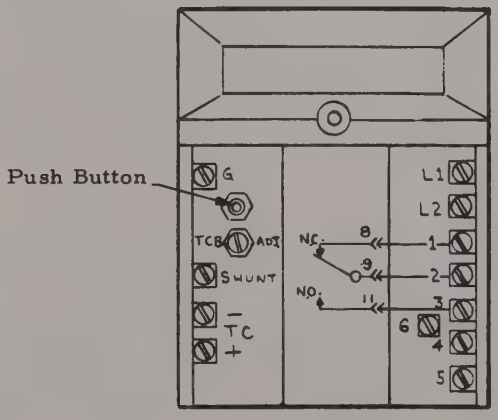


Figure 4

Model 470 Capacitrol
with
Bridge Type TCB

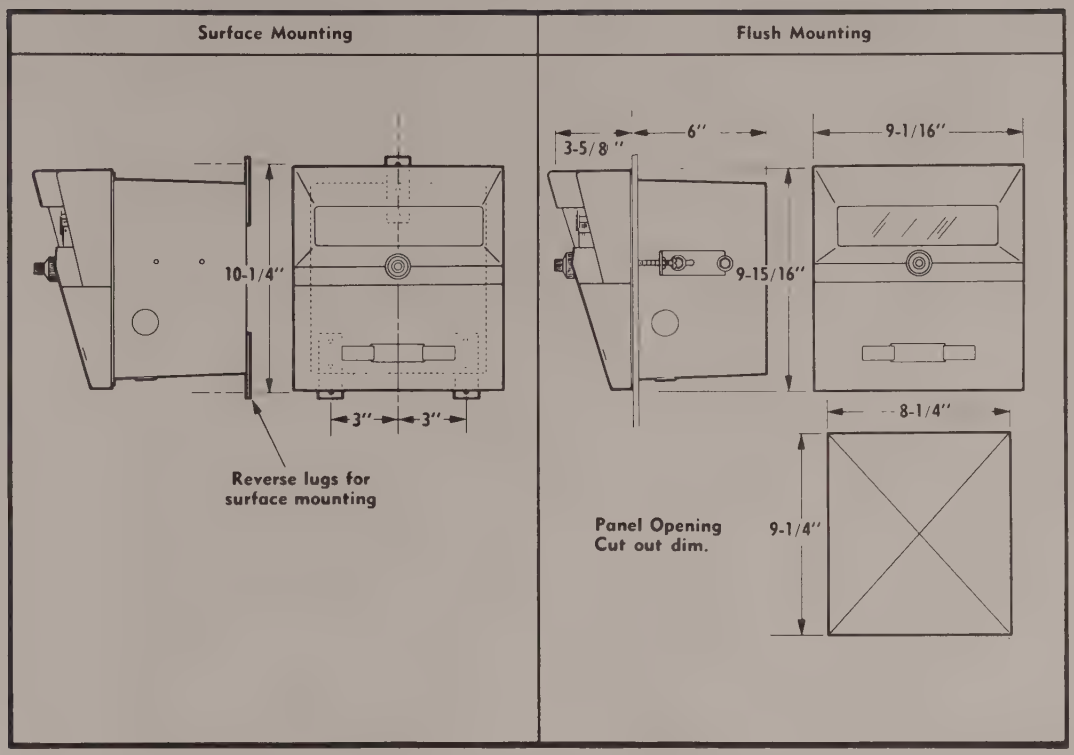


FIGURE 5

MOUNTING DIMENSIONS

(Rigid Mounting)

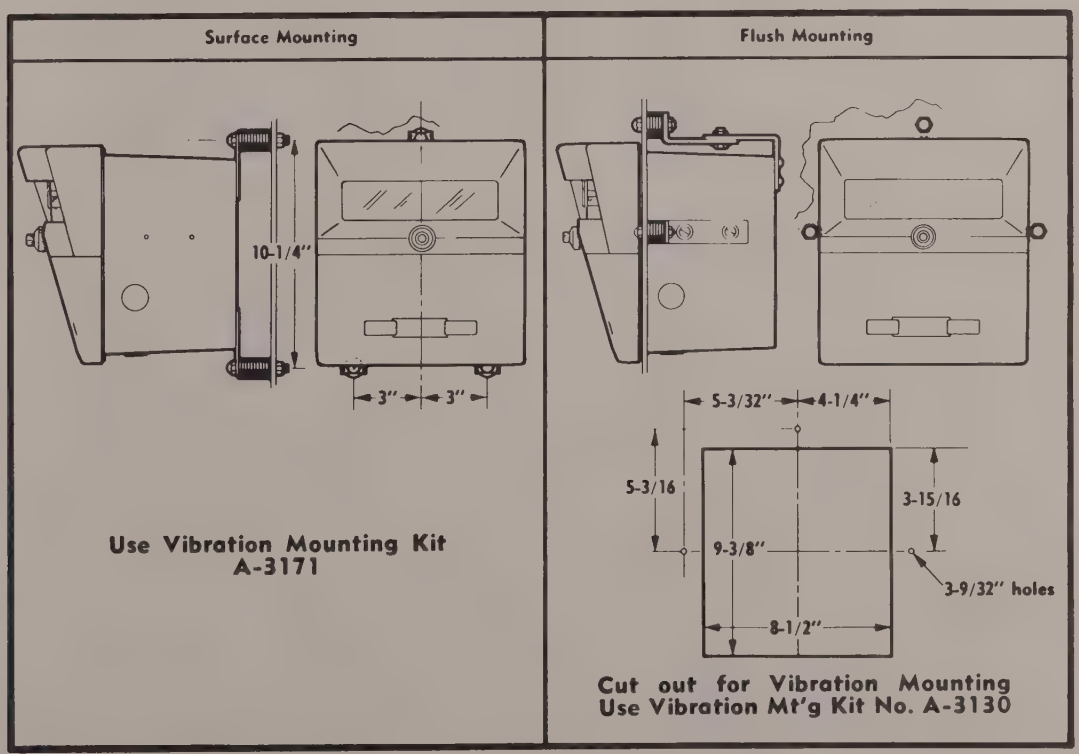


FIGURE 6

MOUNTING DIMENSIONS

(Vibration Mounting)

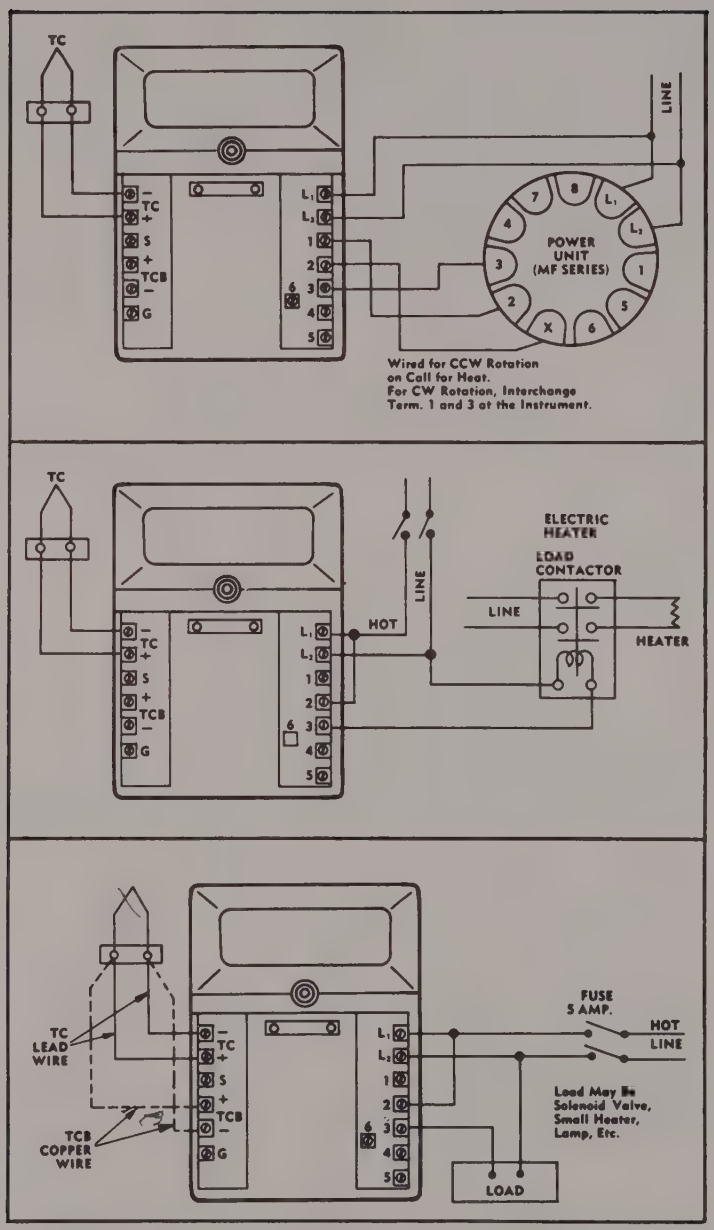


FIGURE 9

EXTERNAL WIRING DIAGRAMS

Meter Shunt Wire

After the instrument is installed, disconnect the jumper wire across terminals marked "Shunt", "TC-" and "TC+". This wire is used to shunt or dampen the meter movement for protection during shipping, handling and installing the instrument, but should be removed for normal operation. Replace the shunt wire when handling or reshipping the instrument and position the red control set pointer fully upscale.

If the meter assembly is removed from the case, an automatic shunt device protects the meter assembly from damage. Other shunt wiring is not required.

Thermocouple Wiring

Do not run thermocouple leadwire with other power or control wiring. However, several thermocouple leadwires may be run in the same conduit if desired.

Use only extension leadwire correct for the type of thermocouple (TC) as specified on the scale. The types most commonly specified are:

Iron-Constantan	Type J
Chromel-Alumel	Type K
Platinum-Platinum 10% Rhodium	Type S
Platinum-Platinum 13% Rhodium	Type R
Heat-Eye	

Ordinary copper wire must not be used as extension leadwire*. See Barber-Colman Thermocouple Catalog for a full selection of thermocouple assemblies and extension leadwire.

Proper polarity (+) and (-) of the leadwire must be observed to obtain correct readings. The negative wire is usually coded red. Correct polarity of the leadwire can be checked by forming a temporary junction at the far end, heating this junction with a match, and noting the deflection of the meter indicator. An upscale deflection is proof of correct polarity of the leadwire.

* Ordinary copper leadwire may, however, be used with the Barber-Colman Land Radiation Pyrometer and some other radiation detectors.

The thermocouple should then be connected to the leadwire and the indicating pointer should again deflect upscale when the thermocouple hot junction is heated. If the indicator moves downscale, reverse only the thermocouple connections at the terminal block since the leadwire has already been correctly connected to the instrument.

Secure the leadwires firmly under the terminal screws. If desired, spade lugs may be used.

Thermocouple Break Protection (TCB)

Each instrument is equipped with thermocouple break protection (TCB). If a break in the thermocouple circuit occurs, the meter indicator will be driven upscale past the control set point, causing the power to the controlled load or process to be turned off and guarding against overheating when an open thermocouple circuit occurs.

Two systems of thermocouple break protection are used. Standard models of the instrument are provided with a small d-c voltage wired into the thermocouple circuit to drive the movement upscale in the event of an open circuit. If so specified, bridge type TCB is furnished. With the thermocouple forming one leg of the bridge circuit, a break in the thermocouple or leadwire produces an unbalance causing the indicator to be driven upscale to shut off control power.

Note: Check to see that jumper wire on underside of chassis is attached to pin ST for models equipped with standard type TCB or to pin BR if bridge type TCB. Models are shipped as ordered, but because of interchangeability of chassis this should be verified.

Standard Type TCB	Although instrument equipped with standard TCB can be operated without TCB connected, its use may be desirable on some applications to guard against overheating in the event of an open thermocouple. The preferred method of connecting TCB is shown in Figure 8. Use extension leadwire as required to make the connections between the instrument TC terminals and the thermocouple head. Use copper wire to connect the TCB terminals to the thermocouple head, observing polarity. Wiring for TCB may be run in the same conduit with thermocouple leadwire. After connections are made, check for any error of indicator reading that may have resulted.

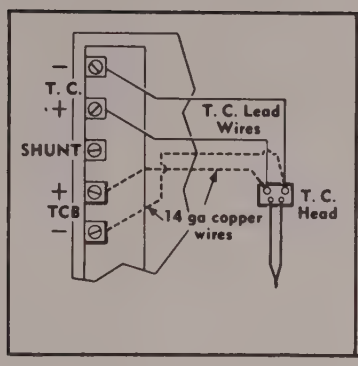


Figure 8

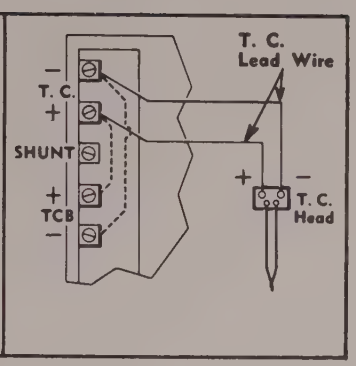


Figure 9

Standard Type TCB (continued)

Although not recommended, an optional method of connecting TCB is to use jumpers at the instrument terminals as shown in Figure 9. As the length of leadwire used affects the amount of TCB compensation required, it is suggested that this method be used only with short leadwire lengths, 10 feet or less, and that the amount of TCB error be checked.

To check for TCB operation, disconnect the thermocouple to simulate a broken thermocouple but leave the TCB wires connected to the leadwire. When the instrument is powered, the indicator should move upscale above the red control set pointer to cause the control to go to the off position. To check for TCB error, power the instrument and read the temperature with the hot junction of the thermocouple held at a steady temperature. Then disconnect the wires at the TCB terminals, and note if the indicated temperature decreases. Reconnect to see if indicated temperature increases. If a shift in reading is noticed, adjust the screw on top of the plastic cover so that the reading with TCB powered is at the same point as read with TCB disconnected. If an adjustment is made, the ambient reading will also be shifted downscale.

Note: Adjustment should be made for correct ambient temperature reading before this check is made. See section on Cold Junction Compensation.

If the instrument is equipped with bridge type thermocouple break protection, the need for any external TCB wiring is eliminated. See Figure 10.

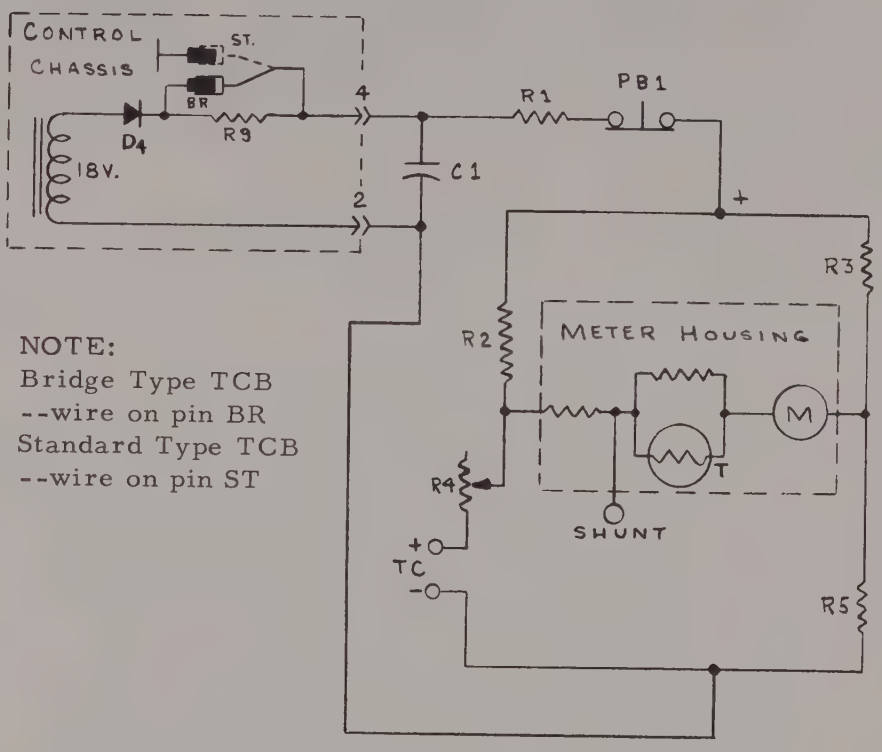


Figure 10

Bridge Type TCB

Bridge type TCB, when properly adjusted, eliminates the error that occurs with other types of TCB circuits. It also compensates for the thermocouple and leadwire resistance, as discussed in the section below. Adjustment is made in the following manner:

Remove the lower front cover, revealing the left-hand terminal strip and the push button over the words "TCB ADJ" with the adjustable potentiometer underneath. With the thermocouple connected and maintained at a steady or fixed temperature, and with the instrument powered, depress the push button and note the meter indicator reading. Then release the push button again and note the indicator reading. If there is a difference between the two readings, adjust the potentiometer with a screwdriver, with the push button released, until the meter indicator reading is the same as the initial reading when the push button was depressed. The proper adjustment is obtained when there is no discernable difference in meter readings with the push button depressed or released.

Bridge Type TCB (continued)	To check for TCB operation, disconnect one of the thermocouple wires to simulate a broken thermocouple. With the instrument powered, TCB is functioning properly if the meter indicator is driven upscale above the red control set pointer causing the power to the load to be turned off.

TCB, either standard or bridge type, cannot be used with radiation detectors or the Series 350 Reference Voltage Source. An instrument with standard TCB requires only that TCB connections not be made. If instrument was purchased equipped with bridge type TCB, and it is later desired to convert for these applications, please consult your Barber-Colman field office.

Thermocouple and Leadwire Resistance Compensation

Standard Type TCB	The external resistance, for which the meter has been calibrated and as marked on the scale, is the combined resistance of the leadwire and thermocouple. Meters equipped for standard thermocouple break protection are usually calibrated for 15 ohms (Ext.Res.15 ohms) which is greater than the combined resistance of most thermocouples plus leadwire used. The balance of the resistance, 15 ohms minus the actual external resistance, is inserted on a removable resistance strip located just under the meter section. The resistance value is marked on the strip and is inserted at the time of the original order. Other values are available.
Bridge Type TCB	Instruments equipped with the bridge type TCB circuit are normally calibrated for 25 ohms which allows up to 20 ohms for the external thermocouple and leadwire resistance. An adjustable potentiometer (R4), located on the left terminal strip inside the lower compartment, is used to compensate for the difference in resistance between the allowable 20 ohms and the actual thermocouple plus leadwire resistance. The proper adjustment of this potentiometer also eliminates any TCB error. See page 12 for adjustment procedure.

Cold Junction Compensation

For measuring temperature, thermocouples are the most commonly used sensing devices. They produce a voltage when there is a temperature difference between the "hot" or measuring junction and the "cold" junction located in the meter assembly. Since the difference in temperature between the hot and cold junctions determines the amount of millivoltage produced, it is necessary to keep the cold junction temperature constant,

or to compensate for any changes that occur at this point. Compensation for temperature changes at the cold junction is accomplished either mechanically or electrically, depending on model variation. Mechanical cold junction compensation, employing a bi-metallic strip, is furnished as standard on non-suppressed range instruments unless otherwise specified. Electrical cold junction compensation is usually provided with suppressed range instruments and can be supplied with any instruments that have bridge type TCB. See Figure 11.

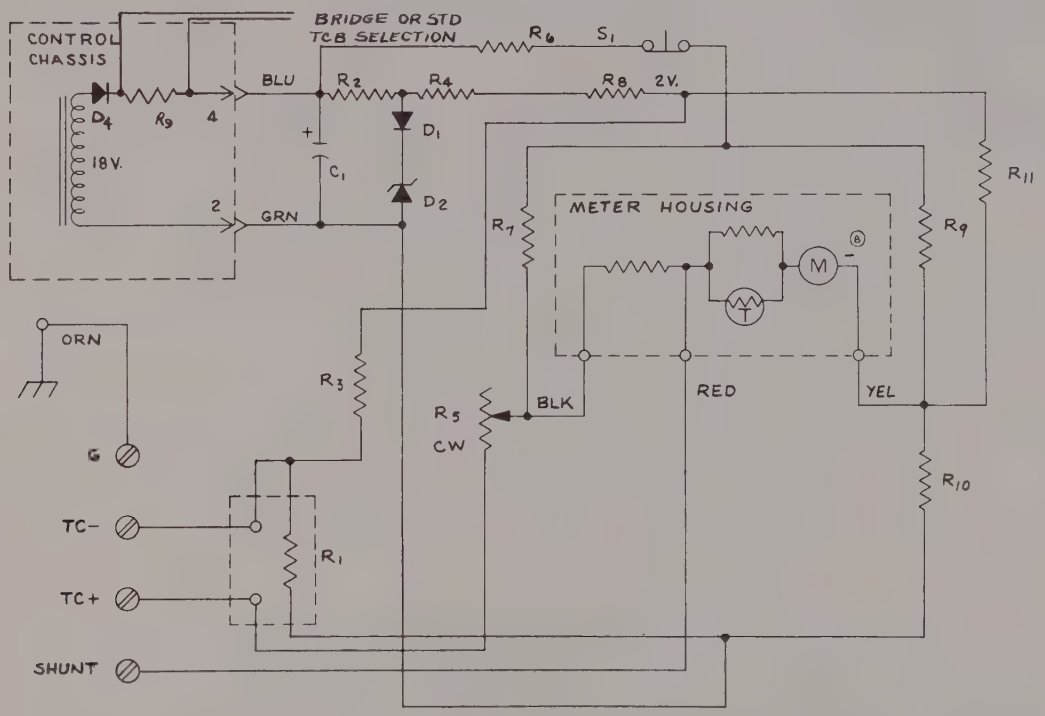


Figure 11

Notes:

1. Electrical cold junction compensation is accomplished by utilizing the resistance change, due to temperature, of resistor R1. Value depends on type of thermocouple used.

2. With electrical cold junction and suppression, value of R10 depends on the type of thermocouple and the amount of suppression desired.

Standard or Bridge TCB with Mechanical Cold Junction

After the instrument has been mounted, the cold junction reading of the meter should be checked. If the instrument is standard (i.e., with mechanical compensation), the cold junction check is made in the following manner:

Disconnect power leads and TC leadwire at the instrument. The indicator should come to rest at the ambient temperature of the meter; it is not supposed to read zero. Place a thermometer at the TC instrument terminals to read ambient temperature.

If the pointer does not indicate the ambient temperature, slowly adjust the screw located on top of the meter cover until it does. Because cold junction compensation is automatic, further corrections for changes in the ambient temperature need not be made.

Bridge TCB with Electrical Cold Junction

If the instrument has a non-suppressed range but is equipped with the electrical cold junction feature and bridge type TCB, check for proper cold junction adjustment according to the following:

The meter indicator should read zero when the instrument is unpowered. If the meter is not at zero, adjust the screw located on top of the meter cover until zero is obtained. Connect a jumper wire between TC- and TC+ and with the instrument powered, adjust the TCB potentiometer so no indicator movement occurs when the TCB push button is depressed and released. Place a thermometer at the TC instrument terminals to measure the ambient temperature reading. With the instrument still powered, the meter indicator reading should be the same as the ambient temperature reading. Further adjustments are not required because of the automatic electrical cold junction compensation.

For instruments with a suppressed range using electrical cold junction compensation:

The meter indicator should come to rest at the lowest temperature reading on the scale when the instrument is unpowered. If it does not, slowly adjust the screw located on top of the meter cover until it does. The meter is then properly adjusted and needs no further adjustment because of automatic electrical cold junction compensation.

OPERATION

Control Action

The red control set pointer is adjusted by use of the knob located just below the indicating scale. The black indicating pointer will move to indicate the temperature at the thermocouple. Control action of the Model 472P is instantaneous because solid state devices operate without warm-up time. From start-up, the red light on the front panel will glow until the meter indicator approaches the control set pointer and the region where proportioning action occurs. At this point the red and green light will cycle on and off until the indicator moves out of this region. When the red light glows, terminals 2 and 3 of the internal relay are closed applying power to the load. When the green light glows, terminals 2 and 1 are closed, removing power from the load.

Control Adjustments

Final control action adjustments should be made after the unit has been in operation 45 minutes and has obtained maximum stability. The controls are accessible by removing the lower front cover, which is removed by first loosening the two screws.

Proportioning Band and Cycle Time Adjustments:

The PB and CT adjustments are inter-related so both adjustments are used together to obtain the desired settings. In order to obtain close tolerance control, the proportioning band and cycle time setting are dependent on the response time of the process. When using the instruments with loads that have a large thermal mass and also have a slow response time, the PB setting should be in the vicinity of 2% of full scale with the cycle time around 25 seconds. For loads that have a small thermal mass and faster response, the proportioning band should be increased and the cycle time decreased.

The minimum cycle time varies from about 3 seconds with a 5% PB setting to about 30 seconds with a 0.5% PB setting. The actual cycle time will vary with the PB setting. With a decrease in PB, the cycle time will increase. For a particular PB setting, the cycle time can be adjusted to a maximum of four times the minimum cycle time. Turning the cycle time adjustment clockwise will increase the time period of one cycle, and counterclockwise will decrease it.

The proportioning band adjustment varies the time proportioning range from 0.5 to 5% of full scale. Turning the PB adjustment counterclockwise decreases the proportioning band; clockwise increases it.

To obtain close tolerance control, and also insure longest life of the contactor and relay, the proper adjustments are obtained in the following manner:

When the controlled load temperature or the meter indicator has reached control set point, turn the proportioning band adjustment fully CW to obtain the maximum proportioning band; then turn

the cycle time adjustment CW increasing the cycle time until the meter indicator or some external monitoring device indicates that the controlled load temperature has a cyclic nature. This would show on the meter as an up and downscale movement of the black pointer. If cycling occurs, turn the cycle time adjustment CCW in small increments, letting the controlled load stabilize after each adjustment. The cyclic variation of the meter indicator and the load will decrease, with the proper cycle time adjustment occurring just at the point where there is no perceptible indicator movement. If no cyclic temperature variations occur even with the cycle time adjustment turned fully CW, turn the proportioning band adjustment CCW in small increments (being sure to let the controlled load stabilize after each adjustment), until a small cyclic temperature variation is noted on the meter indicator. At that point either increase the proportioning band slightly or decrease the cycle time in small increments until no perceptible meter movement occurs. With these settings temperature variation of the controlled load is minimized. If some temperature variations can be tolerated, the cycle time can be increased to reduce relay and contactor contact wear.

Reset:

A "reset" adjustment (the slotted shaft) is located on the right front of the plug-in control chassis, accessible by removing the lower compartment cover.

Reset adjustment provides a means of aligning the meter indicator with the red control set pointer to correct for offset. If the meter indicator does not coincide with the red control set pointer after the controlled load has become thermally stable, an alignment adjustment should be made. Use a small screwdriver to reposition the reset adjustment capacitor. Turning the reset adjustment counterclockwise will decrease the percent on time, thereby shifting the meter downscale so as to produce a lower temperature. Conversely, turning the reset adjustment clockwise will increase the percent on time, causing the meter indicator to shift upscale and produce a greater temperature. The reset adjustment should be in small increments with sufficient time allowed after each adjustment to permit the controlled load to again become thermally stable. The proper reset adjustment occurs when the meter indicator coincides with the control set pointer when the load is thermally stable.

Differential:

A potentiometer is factory adjusted to require approximately a 0.006" motion of the pointer to cause the control action to change from on to off. This setting handles the majority of applications and should not be readjusted except by a qualified instrument repair man. If it is desired to change the operating differential of the instrument relay, remove the control chassis to expose the potentiometer which is adjustable from the side. Turn the potentiometer CW with a small screwdriver to widen the differential, and CCW to reduce it. Too narrow an operating differential may cause a chatter of the instrument relay.

MAINTENANCE

Routine Servicing

Servicing of the instrument, in the usual sense, is not required. It is recommended, however, to make routine checks of the condition of the thermocouple, extension wire and power connections. Meter accuracy may be verified from time to time. The frequency of these checks may vary from one month to three months, depending on the extent of usage, accuracy required and the seriousness of any problems that may be created due to possible "down time".

Spare parts for emergency servicing should be kept on hand. Where a number of instruments are located together, the plug-in parts are interchangeable to allow minimum inventory.

When trouble is encountered, the service man should familiarize himself with the process and instrument application to determine the exact function of the instrument as applied. The instrument trouble usually can be traced to two basic problems: measurement or control.

Measurement or Control Trouble

Measurement trouble can be detected by observing the pointer position. If the measured temperature is known to be in error, check the following:

1. Open or broken thermocouple, leadwire or connector. Check visually or with a volt-ohmmeter.

2. Deteriorated thermocouple. Compare reading with a test thermocouple or check output with a Barber-Colman portable potentiometer.

3. Ascertain that the instrument is grounded.

4. Accidental shorts, grounds or moisture in the leadwire (especially with asbestos type insulation).

5. High resistance in leads due to loose connectors, poor splicing, dirty switch contacts, and other faulty connectors.

6. Problems caused by vibration or shock.

7. Meter accuracy. This can be checked with a Model 330P portable potentiometer.

8. Errors due to oil and grease. Do not oil or grease any part of the instrument.

9. Incorrect cold junction (ambient) setting. The correctness of this setting should be checked following any other meter servicing.

10. Incorrect TCB adjustment (see section on Thermocouple Break Protection).

Control trouble may be detected by observing control point and indicator pointer position. If control action does not occur at control point, do the following:

1. Check electrical connectors and correctness of line voltage. Ascertain as to whether trouble is internal or external to the instrument.

2. Adjust manual reset as described in page 18.

3. If the instrument does not operate (i.e., red light does not glow), make sure the meter indicator is downscale from the control set point and turn the reset adjustment through its entire adjusting range. If the instrument then turns on, let the controlled load stabilize, after which proper reset adjustment can be made as described under Control Adjustments. If the instrument does not turn on, further servicing or replacement of the control chassis is suggested.

Calibration Check

The instrument has been calibrated at the factory to the specified limits of accuracy. No further adjustment need be made. If, however, it is later decided to check the calibration, obtain a Barber-Colman Model 330P Portable Potentiometer, or its equivalent, and perform the following:

Standard TCB Mechanical Cold Junction	If instrument is equipped with standard TCB and mechanical cold junction compensation: Follow directions outlined in the Model 330P Instruction Manual on page 11.

If instrument is equipped with bridge type TCB:

Bridge TCB with Mechanical or Electrical Cold Junction

Remove the TC wire and short out the TC terminals by connecting a jumper wire between terminals marked TC- and TC+. Then, with the instrument powered, adjust the TCB potentiometer so no meter indicator movement occurs when the TCB push button is depressed and released. With the jumper wire then removed, and the instrument unpowered, connect a Barber-Colman 330P (or equivalent) to the thermocouple terminals and follow instructions stated below.

Bridge TCB with Mechanical Cold Junction

If instrument has mechanical cold junction compensation:

Procedure for calibrating is as outlined in the Model 330P Instruction Manual -- except that the Model 330P must be set for zero external resistance instead of the external resistance marked on the scale.

Bridge TCB with Electrical Cold Junction

If the instrument has electrical cold junction compensation and a non-suppressed range:

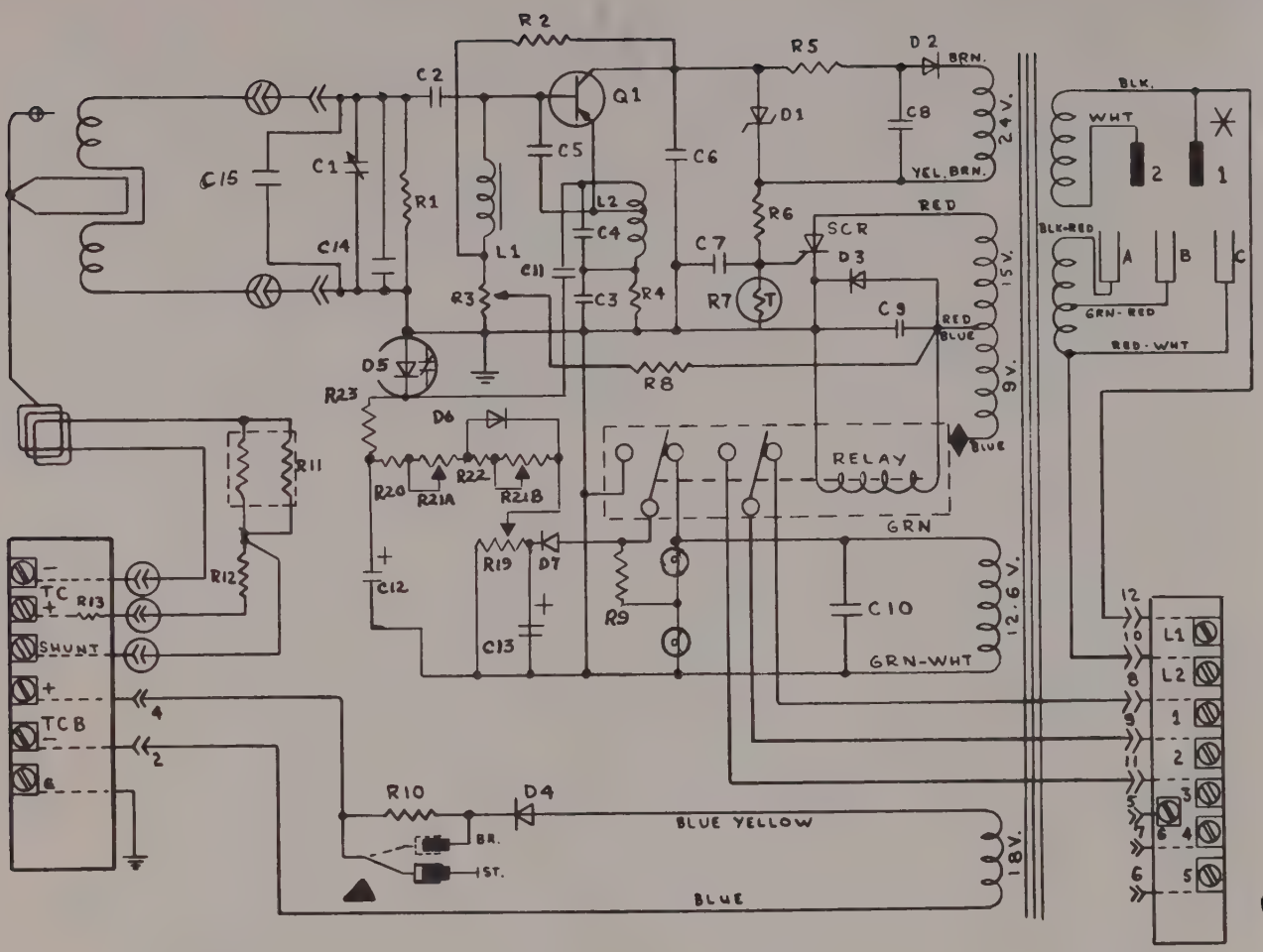
Calibrating procedure is as outlined in the Model 330P Instruction Manual except for the following: The Model 330P must be set for zero external resistance, and for a zero cold junction setting instead of ambient. Since most thermocouple tables are based on 32°F reference temperature, the 0°F millivoltage equivalent has to be added (algebrically) to the desired temperature millivoltage equivalent. For example, the proper 400°F I/C setting on the potentiometer would be:

(0°F) = -0.89 mv, and 400°F = 11.03 mv

11.03 - (-0.89) = 11.92 mv, which is the proper setting

Suppressed range instruments:

These models require a special procedure for calibrating the instrument. Contact your Barber-Colman field office if a calibration check is believed to be necessary.



✳For 120 v. connect A to 1 and C to 2.
For 208 v. connect B to 2.
For 240 v. connect A to 2.

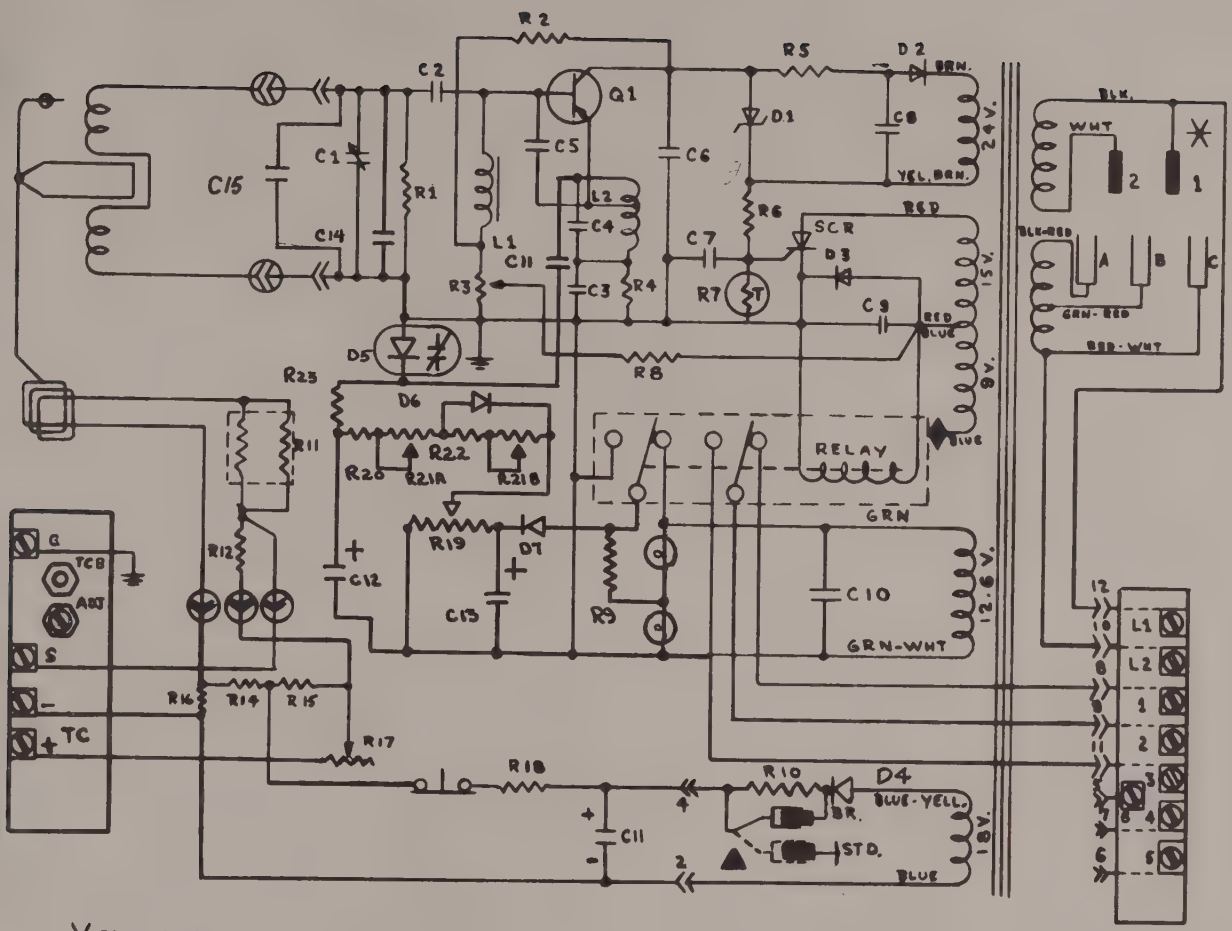
◆ This connection not used on this model.

▲ Jumper in control chassis
-to pin BR for bridge type TCB
-to pin ST for standard type TCB

MODEL 472P WITH STANDARD TCB
INTERNAL WIRING DIAGRAM

FIGURE 12

F-12635
Rev. 4-65



✳For 120 v. connect A to 1 and C to 2.
For 208 v. connect B to 2.
For 240 v. connect A to 2.

♦ This connection not used on this model.

▲ Jumper in control chassis
-to pin BR for bridge type TCB
-to pin ST for standard type TCB

MODEL 472P WITH BRIDGE TYPE TCB
INTERNAL WIRING DIAGRAM

FIGURE 13

Replacement Parts List

Item	Part Number	Description
C1	39-160-1	2.9-35 mmf Capacitor
C2, C3	39-203	270 mmf Capacitor
C4	39-080	47 mfd Capacitor
C5	39-089	5 mmf Capacitor
C6	39-103	.01 mfd Capacitor
C7, C8, C9, C12, C13	39-153	50 mfd Capacitor
C10	39-196	.22 mfd Capacitor
C11	39-068	39 mmfd Capacitor
C14	39-212	8 mmfd Capacitor
C15	39-013-1	15 mmfd Capacitor
D1	37-093	Zener Diode
D2	EYZP-384	Diode
D3, D4, D6, D7	37-030	Diode
D5	37-060	Var. Volt. Cap. Diode
L1	41-130	Choke
L2	41-133	Choke
Q1	31-050	Transistor (2N2188)
R1	CYZR 170-1	22 k Resistor
R2	40-082	33 k Resistor
R3	BYZR 23-6	1 k Potentiometer
R4	40-077	270 ohm Resistor
R5	CYZR 133-2	1.5 k Resistor
R6	CYZR 170-71	390 ohm Resistor
R7	31-048	4850 ohm Thermistor
R8	CYZR 170-43	220 k Resistor
R9	40-094	22 ohm Resistor
R10	CYZR 170-9	68 k Resistor
R11	A-3049-1	Temperature Compensator (two resistors)
R12	A-1847	Multiplier (specify range)
R19	BYZR 83-5	200 ohm Adjustable
R20	40-019-1	100 k ohm
R21 A and R21B	29-147	1 and 5 megohm Dual Potentiometer
R22	CYZR 170-13	470 k
R23	CYZR 170-41	1 megohm
SCR	37-059	Silicon Controlled Rectifier
	A-5521	Relay
	30-142	Transformer

Model 471P with Standard TCB Only

Item	Part Number	Description
R13	A-3497	External Resistance Compensator

Model 471P with Bridge Type TCB

R14	CYZR-326-54	2.5 k Resistor
R15	40-162	10 k Resistor
R16	CYZR-326-103	5 ohm Resistor
R17	29-133	25 ohm Potentiometer
R18	40-070-2	47 k Resistor

Suggested Replacement Parts to Keep on Hand

Quantity	Part Description	Part Number
2	MAZDA Pilot Lamps	36-034
1	Replacement Thermocouple	Barber-Colman can supply thermocouple assemblies, components or wire for any requirement you may have. If need be, delivery will be made in 48 hours. Contact your nearest Barber-Colman field office.
1	Indicating Meter Assembly	A-6175
1	Control Chassis	A-6015

We do not recommend electronic component replacement except by well equipped instrument repair shops.

Barber-Colman, Industrial Instruments Division, maintains service and repair facilities in many major cities in the United States and Canada. Consult your yellow page directory.

MATERIAL WARRANTY

All equipment except tubes, photocells, and thermocouples, which within one year from date of shipment is found to have been originally defective, will be repaired (replaced if necessary) free of charge, if returned immediately, prepaid, to the Factory at Rockford, Illinois.

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